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Evaluating the Global Ocean Biogeochemistry models used in the Global Carbon Budget with the International Ocean Model Benchmarking (IOMB) system.

Scientific Objectives

- ✓ To evaluate the global ocean carbon cycle model performance using the International Ocean model benchmarking System (IOMB).
- ✓ To include/develop targeted metrics with respect to the ocean carbon sink assessment.

Methods

International Ocean Model Benchmarking (IOMB) System.

- ✓ A python-based open-source, multi-model validation tool for evaluating the overall performance of the ocean carbon cycle models, using a set of statistical metrics including bias, RMSE, annual cycle phasing, spatial distribution etc (Fu et. a., 2022), developed from International Land Model Benchmarking (ILAMB) System (Collier et. al., 2018, Hoffmann et. al., 2014).
- ✓ The relative errors (ε) are computed and transform them into normalised scores on the unit interval via an exponential function given by$s = e^{-\alpha\varepsilon}$,
- ✓ The overall score ($S_{overall}$) for a given variable and the data is a composite of the suite of metrics

$$S_{overall} = \frac{S_{bias} + 2S_{rmse} + S_{phase} + S_{iav} + S_{dist}}{1+2+1+1+1}$$

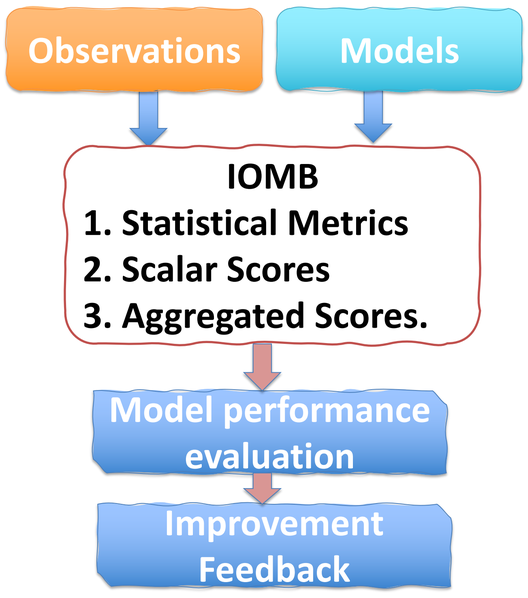

Figure 1. Schematic diagram of International Ocean Model Benchmarking System.

Present day mean of air-sea CO_2 flux from GCB models

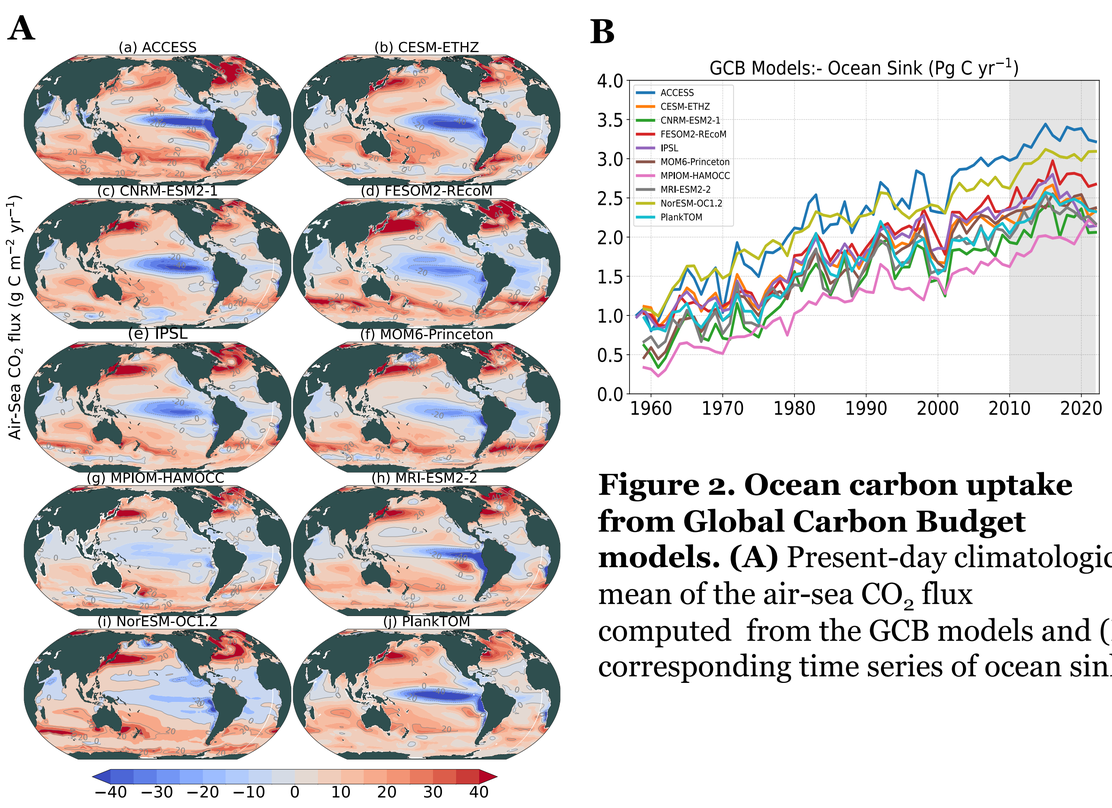

Figure 2. Ocean carbon uptake from Global Carbon Budget models. (A) Present-day climatological mean of the air-sea CO_2 flux computed from the GCB models and (B) corresponding time series of ocean sink.

- ✓ Biases and uncertainties in the GCB model estimates of the ocean carbon sink may be due to imperfections in the representation of physical (e.g., transport, mixing) and biogeochemical processes, as well as in the forcing fields.

Preliminary Results

Scores generated using IOMB System.

(a) Sea Surface Temperature **(b) Sea Surface Salinity**

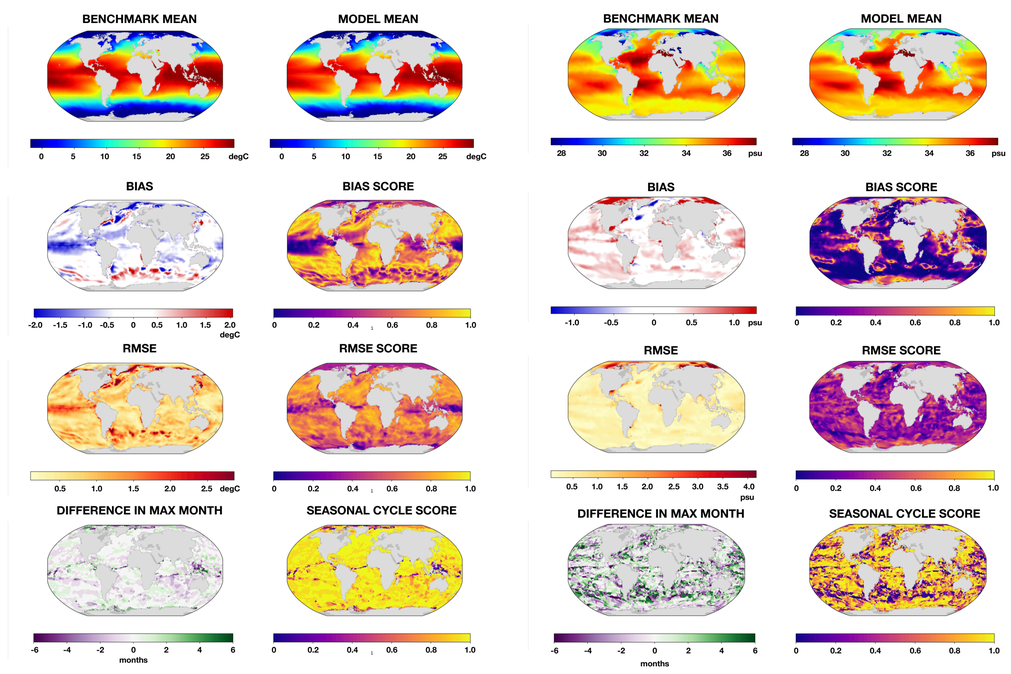

Figure 3. IOMB generated spatial maps of statistical metrics for a single model and its corresponding scores for (a) sea surface temperature and (b) sea surface salinity from the model FESOM2-REcoM.

Overall Score of GCB models from the IOMB system

Variables of Interest	ACCESS	CESM-ETHZ	CNRM	FESOM2-REcoM	IPSL	MOM6_Princeton	MRI-ESM2	NorESM_OC1	PlankTOM
Physical drivers									
Temperature									
Sea Surface Temperature	0,791	0,803	0,783	0,774	0,78	0,788	0,796	0,769	0,723
Temperature at 200m	0,283	0,282	0,281	0,285	0,281	0,286	0,282	0,288	0,274
Temperature at 700m	0,153	0,151	0,151	0,151	0,153	0,154	0,152	0,154	0,152
Salinity									
Sea Surface Salinity	0,528	0,573	0,55	0,521	0,533	0,549	0,558	0,526	0,554
Salinity at 200m	0,281	0,309	0,284	0,291	0,324	0,301	0,302	0,319	0,28
Salinity at 700m	0,175	0,189	0,2	0,183	0,229	0,185	0,203	0,198	0,179
Mixed Layer Depth									
Mixed Layer Depth		0,655	0,631	0,51	0,514	0,624	0,525	0,549	
Carbon									
Alkalinity									
Surface Alkalinity	0,39	0,437	0,431		0,415	0,392	0,415	0,425	0,398
Dissolved Inorganic Carbon									
Dissolved Inorganic Carbon	0,429	0,425	0,441		0,438	0,417	0,441	0,43	0,393
Ecosystems									
Chlorophyll									
Sea Surface Chlorophyll		0,368		0,374	0,355	0,37	0,325	0,328	
Chlorophyll at 100m		0,415		0,377	0,432	0,417	0,407	0,382	
Chlorophyll at 200m		0,313		0,278	0,375	0,326	0,339	0,272	
Oxygen									
Sea surface oxygen						0,521	0,515	0,524	
Oxygen at 100m						0,468	0,46	0,469	
Oxygen at 200m						0,456	0,465	0,438	

Figure 4. International Ocean Model Benchmarking System generated overall score for GCB models: Summary of overall score for GCB models with special reference to physical drivers: temperature (surface, 200m, 700m), salinity (surface, 200m, 700m), chlorophyll (surface, 100m, 200m), and oxygen (surface, 100m, 200m), respectively. All scores are generated via validating against WOA/GLODAPv2.2022 observations. All scores are relative to the corresponding models in the row. Grey colour represents no data available.

Summary and Outlook

- ✓ Preliminary analysis suggests that the overall score of the physical drivers in the GCB models are better than that of the carbon and ecosystem variables.
- ✓ Furthermore, the addition of new targeted metrics (Revelle factor, AMOC, stratification indices, CFCs) and more observational data is inevitable to understand the full carbon cycle in GCB models.

References:

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